The effect of early marriage timing on women's and children's health in Sub-Saharan Africa and South West Asia

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Abstract

Background. Age of marriage is a barrier to mother's health care around pregnancy and children health outcomes.

Objective. We provide evidence on the health benefits of postponing early marriage among young wives (from age 10-14 to age 15-17) on women's health care and children's health for Saharan Africa (SSA) and South West Asia (SWA).

Methods. We use data for 39 countries (Demographic and Health Surveys) to estimate the effects of postponing early marriage for women's health care and children's health outcomes and immunisation using matching techniques. We also assess if women's health empowerment and health constraints are additional barriers.

Findings. We found that in SSA, delaying the age of marriage from age 10-14 to age 15-17 and from age 15-17 to age 18 or above leads to an increase of maternal neotetanus vaccinations of 2.4% and 3.2% respectively, while gains on the likelihood of postnatal checks is larger for delaying marriage among the youngest wives (age 10-14). In SWA, the number of antenatal visits increases by 34%, while the likelihood of having a skilled birth attendant goes up to 4.1% if young wives postpone marriage. In SSA, the probability of children receiving basic vaccinations is twice as large and their neonatal mortality reduction is nearly double if their mothers had married between age 15-17 instead of at age 10-14. The extent of these benefits is also shaped by supply constraints and cultural factors. For instance, we found that weak bargaining power on health decisions for young wives leads to 11% (SWA) fewer antenatal visits and 13% less chances (SSA) of attending postnatal checks.

Conclusion. Delaying age of marriage among young wives can lead to considerable gains in health care utilisation and children health in SSA and SWA if supported by policies that lessen supply constraints and raise women's health empowerment.

Keywords:
Timing of early marriage; prenatal care; child mortality; health empowerment; Sub-Saharan Africa; South West Asia.

1. Background

Early marriage is not only a serious human rights violation driven by socio-cultural factors and poverty but it is also a significant barrier to women and children's health, as girls have not yet attained full maturity and the capacity to act autonomously [1, 2] The associated risks on wellbeing and health due to early marriage are widely acknowledged. Young girls who married early begin child-bearing soon after marriage leading to increased health risks from complications in pregnancy, low infant birth weight and often death during delivery. Other risks for young married girls are due to their short-birth spacing, [3] and higher chances of contracting HIV. [4] Inadequate access and under-utilization of healthcare services are additional reasons for poor health outcomes of young married girls as their decisions to seek care are set back because of their low household wealth and low education. [5, 6] Hence, policies that advocate and support later marriage for young girls has significant health benefits both for young married girls and their children.

Specific country studies show the lack of access to basic health coverage among early married mothers (denoted as EMM hereafter). For instance, Nasrullah [7] find that 73% of EMM in Pakistan have a decreased likelihood of having any prenatal care and increased chances of delivery by unskilled birth attendants, twice the amount compared to non-EMM. Similarly, child marriage in Niger is negatively associated with the frequency of antenatal visits and having a skilled birth attendant at delivery. [8] Moreover, the risk of malnutrition is higher in young children born to girls who married young. [9]

Although many countries have established laws prohibiting early marriage, often these laws are not based on revisions of minimum age of marriage making them difficult to enforce. [10] For the group of girls who ended up marrying very young beyond their will, however, a forward shift on their age of marriage by a few years can be an intermediate step to lessen the negative effects on health through their increasing intra-household bargaining power and autonomy.

Improved agency for young girls could lead to a larger access and control over resources, more mobility outside the community, as well as their ability to negotiate health systems more efficiently. [11] In addition, a few more years outside of marriage can increase the likelihood of these young girls to stay in education [12, 13] and, relatedly, their degree of health literacy. [14]

The aim of the paper is twofold. The first objective is to offer new evidence on the impact of the timing of early marriage among the youngest wives on a wide range of women's and children's health ex-post outcomes for 39 countries in sub-Saharan Africa (SSA) and South West Asia (SWA). In particular, we investigate the benefits of delaying early marriage among the youngest EMM (i.e., marrying at age 15-17 instead of marrying at age 10-14) on health service use (antenatal care, skilled birth attendance, vaccinations and postnatal checks) as well as in terms of their children's immunization uptake, their mortality (neonatal and infant) and nutrition (stunting).

The second objective is to assess whether young wives' health empowerment, access to health services and supply constraints are additional barriers for both their health and the health of their children (after isolating contextual factors driving both marriage decision and health outcomes). To evaluate this, we generate matched sub-samples for the EMM and non-EMM groups with similar characteristics (e.g., family composition, education, family wealth and other socio-economic community variables) by propensity score matching.

We focus on the SSA and SWA as they account for 55% of the world's child marriage prevalence and the 10 countries with the highest prevalence are from these two regions. Also, SSA and SWA are the furthest away from health unequal. For instance, OECD countries have an antenatal coverage of nearly 90%, while in SSA and SWA this is below 50%. [15] In 2013, SSA contributed roughly half (3.1 million) of under-5 deaths worldwide and southern Asia almost a third (2.02 million). [16]

2. Methods

2.1 Data

The analysis is based on 39 Demographic and Health Surveys (DHS) from the SSA and SWA regions. [17] We use the more recent DHS for each country (for details of the countries and surveys' years see Online Appendix 1, Table 1). DHS surveys are nationally representative household samples for LMICs and they are an important source for population health studies [18, 19] due to their comparability, quality and coverage. The primary working sample are women aged 20 to 29 years who had their last baby born alive in the 5 years preceding the survey. For this group, we compare women (and their children) who first married or entered into union between ages 11 and 17 to those who married at age 18 or older. The lower bound of age 20 is used to avoid both measurement error in age of marriage and girls below age 18 where there is uncertainty on whether they will eventually marry, while the upper bound of 29 years of age is chosen to account for decreasing fertility patterns. We created separated samples for maternal and child health variables. As shown by Table 1, sample sizes vary from 209,617 (SSA) and 104,713 (SWA) for the outcome `skilled birth attendant present at birth', to 37,983 (SSA) and 21,544 (SWA) for the outcome `stunting'.

[Table 1 here]

2.2 Outcomes

The first set of indicators includes outcomes for women's health seeking behaviour around pregnancy. That is, the number of antenatal visits (measured the intensity of prenatal care), neotetanus vaccinations (whether mothers had been given toxoid injections during pregnancy), skilled birth attendant (whether a doctor, nurse or midwife was present at birth), and postnatal checks (whether the baby had been checked two months after delivery). The second group of indicators contain outcomes for children's health care after birth, mortality and malnutrition.

Children's basic vaccinations include BCG, DPT, polio and measles during the first year of life. Birth histories covering a 5-year period provided by women were used to calculate child mortality binary indicators: neonatal mortality (if the child died within the first month of life) and infant mortality (if the child died before first birthday). Stunting indicates chronic malnutrition for children below the age of 5.

2.3 Covariates

As well as the key covariates early marriage and timing of early marriage, the analysis includes a wide range of household and community covariates. Household covariates are: number of children at home, male-headed household, mother's working status and religion, mother's body mass index (BMI), father's occupation type, parental education and household wealth. Community covariates include health variables (average number of children under age 4, proportion of underweight mothers), community location (urban/rural) and socio-economic background (a development index based on household assets and proportion of fathers with an upper/non-farm occupation). We also include country variables such as GDP per capita, number of health workers per 1000 people, and proportion of the population with access to improved water and sanitation. [20]

2.4 Statistical Analyses

Because marrying young is not a random event as it is influenced by an array of socio-economic and cultural factors, a comparison of EMM and their children with the group of women marrying later will be biased. To attenuate the selection bias generated by confounding factors we use matching techniques. [21] We attempt to isolate the effect of early marriage controlling for observables (from Table 2) pursuing a twofold approach. First, to estimate the relative benefits of delaying early marriage on mother's health care surrounding pregnancy and children's health outcomes –the first objective of the paper– we adopt a multitreatment

approach. [22] This procedure minimizes the impact of observables in the selection of marriage at different ages. We define three treatments effects: married between age 10 and 14 (treatment 0, $t = 0$); married between age 15 to 17 (treatment 1, $t = 1$); and married after age 18 (treatment 2, $t = 2$). That is, we divide the early married treatment group into two additional treatment groups (i.e., girls married at a very young age and girls married at an intermediate age). Multivalued treatment effects are constructed by contrasting the parameters of the distributions that the outcome variable would have had under each level of treatment, that is, the population-averaged treatment effects of getting treatment 1 instead of 0, treatment 2 instead of 0, and treatment 2 instead of 1. The treatment equation includes household, community health and socio-economic controls as well as country variables and, for the health equation, additional controls used are education and household wealth since they are observed after marriage.

For the second objective of the paper (i.e., the analysis of women's empowerment on health decisions, access to family planning and supply constraints as mediating pathways from early marriage to health), we conduct regressions on matched sub-samples obtained by propensity score matching on the early marriage treatment. Within these regressions, we interact these mediating factors with the categorical variable early marriage. Here, we match on additional covariates for both women and husband education as well as occupation and family wealth. We employ nearest neighbor matching without replacement with a small caliper to generate balancing of covariates among the treated and untreated groups (see Online Appendix 3 for details on the matching procedure and the construction of matched subsamples). Importantly, matched subsamples generated in this manner identifies comparable mothers married before and after age 18. We carry out multilevel estimations on matched subsamples to account for clustering of observations, where level 1 is given by mothers (or children) and level 2 by communities. Estimates for multitreatment effects were obtained using the poparms command

of Stata, propensity score matching estimations using psmatch2, and multilevel analysis with the meglm and melogit commands.

3. Results

3.1 Descriptive

Table 1 shows the distribution of outcomes by age of marriage for SSA and SWA. In both regions, there are significant gaps in health outcomes not only by early marriage groups but also by the timing of marriage. For example, in comparison to EMM who had married between age 10-14, EMM married between age 15-17 are more likely to attend prenatal services by 0.45-0.67 times, they have 4%-9% higher chances to be vaccinated for neotetanus, and an additional 2%-10% chances that a qualified health worker was present at their birth. Equally, infant mortality and stunting rates are between 1%-3% lower for the EMM married between age 15-17. Furthermore, Table 2 shows information on covariates by timing of marriage. There are major differences with women who married earlier being noticeably disadvantaged. For instance, in SSA, households of the women married very young have nearly double the number of children than those from the non-early married group, and they are 30% more likely to be poorest (fall into the bottom quintile of wealth distribution) while for the non EMM group there is only a 17% chance.

[Table 2 here]

3.2 Effects of timing of marriage on health outcomes

Figure 1 contains the estimated densities for the predicted probabilities for each treatment conditional on the other two treatments. Because none of the densities shows any mass with values too close to 0 or 1, estimates do not encounter any common support problems.

[Figure 1 here]

As shown by Table 3 (Panel A) if girls would have had the agency to postpone early marriage this could have far reaching effects on their health-care outcomes. Delaying marriage among the youngest married group of EMM from age 10-14 to age 15-17 (t1 vs t0) has impacts of similar magnitude than delaying EM from age 15-17 to age 18 or older (t2 vs t1) for the outcomes neotetanus vaccinations and postnatal checks. In SSA, for example, the impact of postponing marriage among EMM is of 2.4% and of 3.2% for the age 15-17 versus age 18 or older for the outcome neotetanus vaccinations, though for postnatal checks it is even larger as the contrasting effects of t1 against t0 (=0.039) is higher than for t2 against t1 (=0.021). Equally, for SWA, further benefits are obtained by marriage among the youngest married group of EMM: for number of antenatal visits (t1 vs t0 = 0.34, t2 vs t1 = 0.52) and skilled birth attendant (t1 vs t0 = 0.041, t2 vs t1 = 0.069). Obviously, the largest estimates are when contrasting effects of t2 vs t0.

[Table 3 here]

Moreover, if early married girls falling into the lowest age group (age 10-14) hypothetically had either the agency/empowerment to postpone their marriage or they hadn't been pressured into marriage by their families, communities or the influence of social norms, this would have led to considerable benefits for their children's health (Panel B of Table 3). This is particularly the case for SSA where the probability of children with basic vaccinations is twice as large (0.054 vs 0.028) and the reduction of neonatal mortality is nearly double (-0.009 vs -0.006) if their mothers had married between age 15-17 instead of marrying earlier on at age 10-14. For the two regions, there are also positive effects for infant mortality by postponing marriage among the youngest EMM. It should be noted that for the SSA region estimates are driven by the larger impacts in Western Africa (WA) and Eastern Africa (EA) (see Table 2 of Online Appendix 2 including SSA's sub-regions estimates).

3.3 Mediating effects on the early marriage impact on health

Here we examine supplementary pathways mediating the effect from early marriage to health outcomes using matched sub-samples. We look at whether women's empowerment in health decisions, access to family planning services and supply constraints (i.e., distance to health facilities) account for some of the negative effects of child marriage on health using subsamples of treated and untreated women with similar distributions of observables characteristics (household and community covariates of Table 2). After matching on the propensity score for the treatment variable early marriage, sample sizes of matched subsamples are reduced between 64% (SWA) to 74% (SSA) from the original sample sizes (see Table 3 of Online Appendix 3).

Estimates for the interaction term between these mediating effects and the binary variable early marriage are presented in Table 4. We find that intra-household bargaining power regarding health decisions matters relatively more for EMM than to non-EMM (again, with the two groups having similar background characteristics). The indicator `husbands having control over women's health expenditure' leads to 0.11 (SWA) fewer antenatal visits and 13% less chances (SSA) of going to postnatal checks for EMM in comparison to non-EMM (model M1). Among EMM, access on information on fertility decisions are also affected by lower access to family planning services. In SSA and SWA, `having not heard or not being offered family planning services' (models M2 and M4), is related to 0.10 and 0.20 fewer number of prenatal visits and around 0.30 lower chances of having a skilled professional at birth in either region, as well as to 0.80 or 0.65 fewer chances to attend postnatal checks or children having basic vaccinations (in SWA). Distance to health facilities and related security concerns (model M5) are also extra barriers to health seeking behaviour for EMM. In SWA, for example, EMM have 15% and 24% smaller chances to have access to skilled birth attendants and for children to have received basic vaccinations, respectively.

[Table 4 here]

4. Discussion

We found that delaying age of marriage among young wives in SSA and SWA − which could be accomplished by empowerment and community policies, for instance− can lead to considerable gains in maternal health care utilization and children's health. In SSA, delaying the age of marriage from age 10-14 to age 15-17 and from age 15-17 to age 18 or above is related to an increase of maternal neotetanus vaccinations of 2.4% and 3.2%, respectively, it leads to larger gains on the likelihood of postnatal checks among the youngest married wives, whereas the probability of children receiving basic vaccinations is twice as large and their neonatal mortality reduction is nearly double if their mothers had married between age 15-17 instead of at age 10-14. In SWA, the number of antenatal visits increases by 34%, and the likelihood of having a skilled birth attendant goes up to 4.1% by increasing the time of early marriage.

Differences in estimates by region and by indicator types could be reflecting differential regional bottlenecks on effective coverage as well as differential benefits of increasing young wives' health literacy. In SSA, by delaying their age of marriage until age 15-17, the gains for girls married at age 10-14 of are greater for postnatal checks, child vaccinations and neonatal mortality, whereas in SWA they are relatively greater for neotetanus vaccinations (though there are still improvements in the case of antenatal care, child mortality and stunting). These distinct findings for the two regions may suggest two distinct policy actions.

First, the SSA's finding of the effect that shifting forward the age of marriage has on the youngest married girls in terms of postnatal checks, children vaccinations and neonatal mortality, suggests that in this region further education could have a leading role in better care around birth through a greater ability in accessing and processing new health information. Maternal education enhances healthcare-seeking behaviours for children. [23] Importantly, our estimates validate the fact that health literacy on essential new-born care (ENC) in poor settings

is powerfully shaped by slight changes in mother's behaviour, with education being a strong enabler. For example, postnatal care in SSA is associated with a reduction in neonatal mortality of 0.51-0.34. [24] Our findings are supported by earlier studies [25] showing the pronounced effect schooling has on neonatal mortality for Eastern Africa (the sub-region driving SSA's estimates) and by the fact that most child marriage programs in Eastern Africa have strong education components alongside reproductive health measures. [26, 27] Hence, an effective policy could be to target schools as re-entry points into health care with readmissions of young wives following the birth of a child involving teachers, community leaders, and health service providers. Conversely, as in other studies, [28] we found that the frequency of antenatal visits and skilled birth attendance coverage in SSA have relative lower leverage effects.

Second, for the SWA region, the large impact on the uptake of neotetanus vaccinations for the group of girls married at the youngest age could be the reason behind the estimated effect on the decreased neonatal preventable deaths (of 5 per 1000 live births). Indeed, studies show that neonatal tetanus is an important preventable cause of neonatal mortality. For example, the northern states of Indian (where child marriage is widespread and health services are scanty) account for 56% of deaths in India due to neonatal tetanus. [29] Empowering policies for youngest wives contributing to a delay of their timing of marriage could raise their chances of tetanus vaccination during pregnancy. This is likely to have maximal impact as child brides live in communities where neonatal tetanus is common as most births take place in unhygienic conditions and they are attended to by untrained professionals. [30] Our estimates also show that reductions on children's stunting rates can be significant through delayed marriage, which is critical given the poor levels of nutrition in the region and its' relationship with infant mortality. Thus, SWA's programmes educating young mothers on the importance of neotetanus vaccinations and appropriate feeding practices are vital because of the powerful impacts on neonatal and infant mortality.

Nevertheless, in the matched sample analysis we found that shifting the time of marriage is not enough in silo and needs to be implemented in parallel with other measures lifting economic and cultural barriers withholding EMM's health seeking behaviour. That is, we found that even by isolating household, community and country factors, infrastructure constraints still need to be addressed (such as low access to family planning services and lack of empowerment on health decisions). For example, we found that the weak bargaining power of young wives regarding health decisions leads to 11% (SWA) fewer antenatal visits and 13% less chances (SSA) of going to postnatal checks.

These results have clear policy implications. Direct and indirect costs of accessing health care hit young wives the hardest because of travel times and time spent away from productive work, all of which represent a higher economic burden [28] and, accordingly, a great deal can be attained by reducing distance to health centers in child marriage hotspots. Also, efforts in delivering family planning programs should be strengthened for young wives as its' scarcity leads to short birth spacing, putting a strain on family resources and to higher infant mortality. We also found that increasing intra-household women bargaining power on health decisions is key. Changing socio-cultural perceptions on women's role in a society are essential for interventions to function. Most child marriage programs include empowerment initiative as a primary objective. [27] Our results suggest that more efforts should be put towards empowering girls with health information and skills.

5. Conclusions

Using data for 39 countries from SSA and SWA, this paper empirically assessed the relationship between timing of early marriage and an array of women's health care and children's health outcomes. We also considered whether health empowerment and supply factors are additional constraints on observed poor health behaviour of early married mothers.

We found significant positive effects by increasing age at time of marriage (from age 10-14 to age 15-17) on women's health care utilisation and on children's health. The scope of these benefits, however, vary across regions and outcomes. In addition, we found that the likelihood of these benefits happening can be noticeably increased by removing constraints in the health supply side as well as cultural barriers related to health empowerment.

The paper conveys two vital messages for the post 2015 development agenda and the new Sustainable Development Goals (SDGs). First, success on achievement of SDGs would be hindered if across-goals synergies (SDG3-health and SGD5-gender equality) are not considered. Second, synergies can be implemented through intermediate steps. Policies geared towards giving incentives to move forward the timing of marriage among the youngest wives could yield improvement in women's health care and children's health in the medium term towards the 2030 deadline.

For the next fifteen years, the issue of delaying early marriage should be at the forefront of development policy disadvantaged women and society as a whole. Our analysis shows that the health care benefits of delayed marriage are enormous and so introducing policies that make this a priority should be pursued by countries in the two regions we have studied. Policies are in themselves not enough. Early marriage in many poor countries is locked in with cultural practices and values that undermine the empowerment of women. Policies that address and improve women's voices in decision-making at the local level can enhance their rights in terms of delaying marriage.

Competing interests

The authors declare that they have no competing interests.

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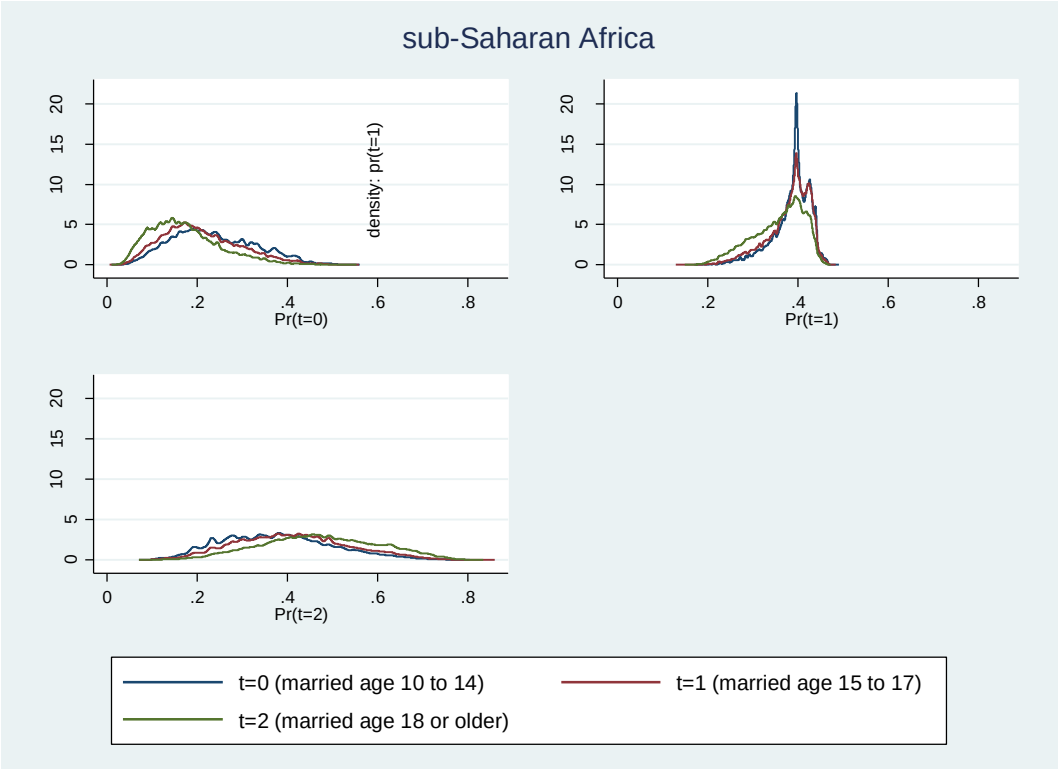

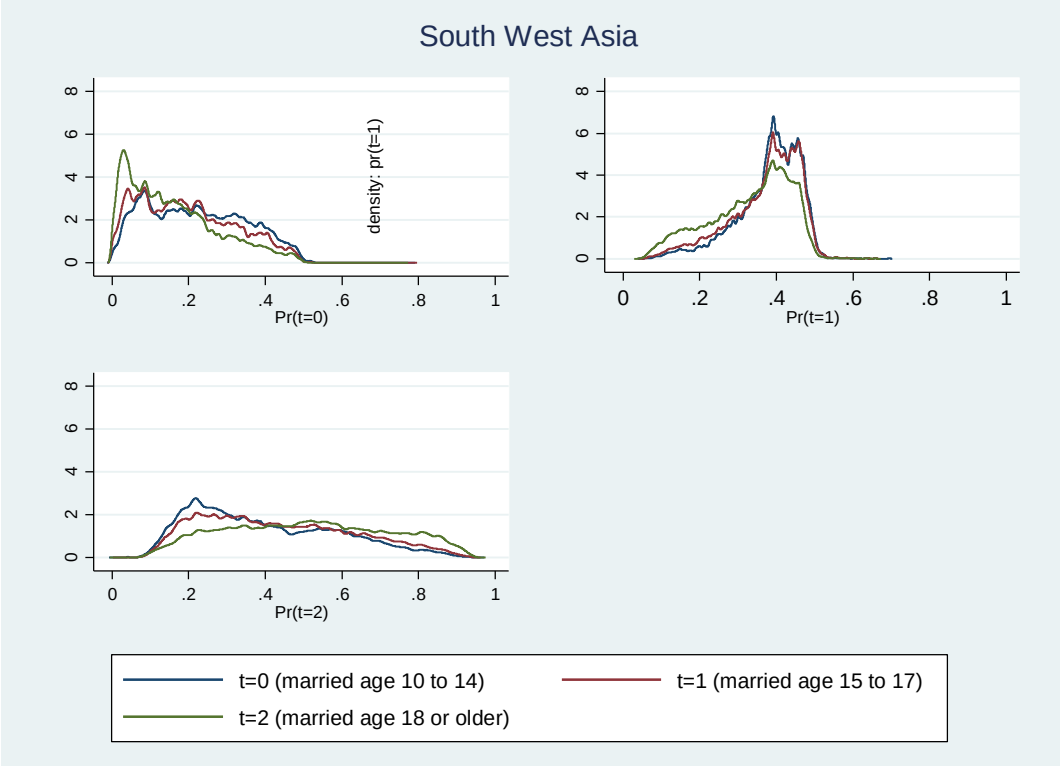

Figure 1. Common support (conditional densities) for multivalued treatment effects by region (Sample: Child vaccinations)

Table 1

Samples' summary statistics and for women health care and children health outcomes.

Sub-Saharan Africa (SSA) and South West Asia (SWA). 39 LMICs DHS surveys 2004-2014

Women's health care	Antenatal visits numbers		Vaccination neotetanus		Skilled birth attendant		Postnatal check	
	SSA	SWA	SSA	SWA	SSA	SWA	SSA	SWA
N	207,614	105,582	209,463	105,896	209,617	104,713	169,870	62,188
Whole sample	3.70	3.55	0.76	0.81	0.07	0.31	0.45	0.24
Early marriage (age 10 to 14)	3.02	2.23	0.65	0.75	0.03	0.17	0.36	0.21
Early marriage (age 15 to 17)	3.47	2.90	0.74	0.79	0.05	0.26	0.44	0.22
Married (18 or older)	4.22	4.94	0.81	0.86	0.09	0.44	0.49	0.31
Early marriage (age 10 to 17)	3.32	2.68	0.71	0.78	0.04	0.23	0.42	0.22

Children's health outcomes	Child basic vaccinations		Neonatal mortality		Infant mortality		Stunting	
	SSA	SWA	SSA	SWA	SSA	SWA	SSA	SWA
N	171,753	105,070	49,100	27,830	49,100	27,830	37,983	21,544
Whole sample	0.21	0.17	0.014	0.017	0.030	0.025	0.31	0.36
Early marriage (age 10 to 14)	0.14	0.13	0.020	0.020	0.040	0.030	0.35	0.43
Early marriage (age 15 to 17)	0.21	0.15	0.013	0.020	0.030	0.028	0.34	0.40
Married (18 or older)	0.25	0.23	0.013	0.013	0.025	0.019	0.27	0.29
Early marriage (age 10 to 17)	0.18	0.14	0.015	0.020	0.033	0.029	0.34	0.41

Notes: (1) Includes 34 SSA countries and 5 SWA countries. See Table 1 (Online Appendix 1) for a list of countries and surveys' years. (2) Working samples include ever married women aged 20-29.

Table 2

Summary statistics (means) of covariates by treatment status (time of marriage)

Variables	SSA			SWA		
	Married (age 10 -14)	Married (age 15 -17)	Married (age 18 or older)	Married (age 10 -14)	Married (age 15 -17)	Married (age 18 or older)
Individual						
Number of sisters	1.353	1.124	0.753	1.238	1.050	0.642
Number of brothers	1.429	1.152	0.754	1.323	1.124	0.692
Household head - male	0.934	0.915	0.893	0.961	0.952	0.900
Mother work	0.569	0.580	0.577	0.334	0.307	0.271
Mother - Muslim	0.496	0.369	0.263	0.412	0.290	0.202
Mother's BMI	23.525	23.781	24.441	22.909	23.910	26.809
Household wealth - Q1	0.298	0.241	0.177	0.266	0.198	0.099
Household wealth - Q2	0.245	0.220	0.178	0.233	0.205	0.141
Household wealth - Q3	0.187	0.199	0.185	0.218	0.219	0.187
Household wealth - Q4	0.151	0.188	0.201	0.180	0.217	0.248
Household wealth - Q5	0.118	0.151	0.258	0.104	0.162	0.326
Father occupation - farm	0.555	0.529	0.396	0.338	0.295	0.201
Father occupation - lower non-farm	0.255	0.279	0.343	0.468	0.473	0.423
Father occupation - upper non-farm	0.190	0.192	0.261	0.194	0.232	0.376
Mother education - none	0.627	0.562	0.470	0.476	0.468	0.393
Mother education - at least some primary	0.271	0.304	0.307	0.320	0.268	0.204
Mother education - at least some secondary	0.102	0.134	0.223	0.205	0.264	0.403
Father education - none	0.620	0.556	0.472	0.464	0.461	0.390
Father education - at least some primary	0.287	0.309	0.303	0.334	0.271	0.199
Father education - at least some secondary	0.094	0.135	0.224	0.202	0.268	0.411
Community						
Number of children under 4	0.430	0.400	0.350	0.283	0.280	0.254
Underweight mothers (%)	0.109	0.094	0.077	0.282	0.271	0.208

Rural community	0.763	0.726	0.618	0.697	0.656	0.558
Development index	-0.309	-0.163	0.137	-0.378	-0.287	0.125
Parents with secondary education (%)	0.142	0.171	0.232	0.295	0.323	0.394
Upper non-farm occupation - father (%)	0.437	0.573	0.713	0.263	0.317	0.557

Note: (1) Additional country controls included log of GDP per capita, proportion of urban population, number of wealth workers per 1000 people, and proportion of population with access to improved water source and sanitation facilities (World Bank, 2015).

Table 3
Effect of age of marriage (multitreatment effects) on mother's health care and children's health outcomes

	SSA			SWA		
	Estimate	CI		Estimate	CI	
Panel A - Mother's health care outcomes						
Antenatal visits numbers						
Married age 15-17 vs age 10-14 (t1 vs t0)	0.085***	0.051	0.120	0.340***	0.229	0.451
Married age 18 or older vs age 10-14 (t2 vs t0)	0.457***	0.422	0.492	0.859***	0.751	0.968
Married age 18 or older vs age 15-17 (t2 vs t1)	0.372***	0.346	0.397	0.519***	0.475	0.563
Vaccination neotetanus						
Married age 15-17 vs age 10-14 (t1 vs t0)	0.024***	0.019	0.030	0.016***	0.006	0.027
Married age 18 or older vs age 10-14 (t2 vs t0)	0.056***	0.051	0.062	0.029***	0.018	0.039
Married age 18 or older vs age 15-17 (t2 vs t1)	0.032***	0.028	0.036	0.012***	0.007	0.018
Skilled birth attendant						
Married age 15-17 vs age 10-14 (t1 vs t0)	0.004***	0.001	0.007	0.041***	0.032	0.051
Married age 18 or older vs age 10-14 (t2 vs t0)	0.027***	0.024	0.030	0.110***	0.101	0.119
Married age 18 or older vs age 15-17 (t2 vs t1)	0.023***	0.021	0.025	0.069***	0.063	0.075
Postnatal check						
Married age 15-17 vs age 10-14 (t1 vs t0)	0.039***	0.032	0.046	0.016***	0.006	0.025
Married age 18 or older vs age 10-14 (t2 vs t0)	0.061***	0.054	0.067	0.041***	0.031	0.050
Married age 18 or older vs age 15-17 (t2 vs t1)	0.021***	0.016	0.027	0.025***	0.018	0.032
Panel B - Children's health outcomes						
Child basic vaccinations						
Married age 15-17 vs age 10-14 (t1 vs t0)	0.054***	0.048	0.059	0.039***	0.027	0.051
Married age 18 or older vs age 10-14 (t2 vs t0)	0.082***	0.076	0.088	0.099***	0.087	0.111
Married age 18 or older vs age 15-17 (t2 vs t1)	0.028***	0.024	0.033	0.060***	0.054	0.066
Neonatal mortality						
Married age 15-17 vs age 10-14 (t1 vs t0)	-0.009***	-0.014	-0.005	-0.005*	-0.011	0.001
Married age 18 or older vs age 10-14 (t2 vs t0)	-0.015***	-0.020	-0.011	-0.016***	-0.022	-0.010
Married age 18 or older vs age 15-17 (t2 vs t1)	-0.006***	-0.009	-0.004	-0.011***	-0.014	-0.007
Infant mortality						
Married age 15-17 vs age 10-14 (t1 vs t0)	-0.015***	-0.021	-0.009	-0.008**	-0.015	0.000
Married age 18 or older vs age 10-14 (t2 vs t0)	-0.031***	-0.037	-0.026	-0.023***	-0.030	-0.015
Married age 18 or older vs age 15-17 (t2 vs t1)	-0.016***	-0.020	-0.013	-0.015***	-0.019	-0.011
Stunting						
Married age 15-17 vs age 10-14 (t1 vs t0)	-0.006	-0.022	0.009	-0.025**	-0.054	0.003
Married age 18 or older vs age 10-14 (t2 vs t0)	-0.048***	-0.063	-0.032	-0.072***	-0.100	-0.044
Married age 18 or older vs age 15-17 (t2 vs t1)	-0.042***	-0.052	-0.031	-0.047***	-0.061	-0.032

Notes: (1) Controls are from Table 2. (2) The contrasting parameters for women health care and their children health outcomes distributions are as follows. (a) t1 vs t0 is the outcome that girls married age 10-14 (t0) would have had if they had married at age 15-17 (t1). (b) t2 vs t0 is the outcome that girls married age 10-14 (t0) would have had if they had married after age 17 (t2). (c) t2 vs t1 is the outcome that girls married age 15-17 (t1) would have had if they had married after age 17 (t2). (3) Delta-method standard errors. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4
Early marriage interactions effects of health empowerment, family planning and distance to health facilities. Linear and logit (odds ratio) two-level multilevel estimates on matched sub-samples.

	SSA					SWA				
	M1	M2	M3	M4	M5	M1	M2	M3	M4	M5
Outcome: Antenatal visits number										
Early marriage (EM)	-0.299***	-0.202***	-0.274***	-0.168***	-0.270***	-0.490***	-0.378***	-0.844***	-0.579***	-0.514***
Women's health care decision husband	-0.298***					-0.151***				
Women's health care decision husband x EM	0.100***					-0.113**				
Heard of family planning		0.544***					1.056***			
Heard of family planning x EM		-0.066***					-0.198***			
Visited health facility			0.285***					1.505***		
Visited health facility x EM			0.072***					0.245		
Health facility told family planning				0.284***					0.232*	
Health facility told family planning x EM				-0.105***					0.082	
Distance to health facility problem					-0.336***					-0.434***
Distance to health facility problem x EM					0.107***					-0.093*
N (matched sample)	142,926	147,878	146,716	96,880	131,568	64,536	68,400	10,506	8,905	58,349
Outcome: Skilled birth attendant										
Early marriage (EM)	0.664***	0.616***	0.807***	0.563***	0.656***	0.562***	0.668***	0.884	1.133	0.586***
Women's health care decision husband	0.809***					0.826***				
Women's health care decision husband x EM	0.923					0.819***				
Heard of family planning		1.432***					2.912***			
Heard of family planning x EM		1.090					0.703***			
Visited health facility			1.354***					1.451***		
Visited health facility x EM			0.664***					1.203		
Health facility told family planning				1.094*					1.336*	
Health facility told family planning x EM				0.770***					0.459***	
Distance to health facility problem					0.772***					0.583***
Distance to health facility problem x EM					0.936					0.852**
N (matched sample)	147,057	152,256	151,078	98,925	136,000	63,427	67,289	10,888	9,283	57,212

table 4 continued

	SSA					SWA				
	M1	M2	M3	M4	M5	M1	M2	M3	M4	M5
Outcome: Postnatal checks										
Early marriage (EM)	0.926***	0.877***	0.853***	0.848***	0.884***	0.813***	0.910*	0.800	0.794**	1.196**
Women's health care decision husband	1.006					0.773***				
Women's health care decision husband x EM	0.870***					0.982				
Heard of family planning		1.623***					2.168***			
Heard of family planning x EM		1.002					0.791***			
Visited health facility			1.993***					1.655***		
Visited health facility x EM			1.059					1.146		
Health facility told family planning				1.399***					1.777***	
Health facility told family planning x EM				0.928					1.017	
Distance to health facility problem					0.712***					0.781***
Distance to health facility problem x EM					1.045					0.550***
N (matched sample)	120,063	121,484	120,299	75,598	112,925	34,550	36,909	7,297	5,846	27,778
Outcome: Children's vaccinations										
Early marriage (EM)	0.881***	0.872***	0.881***	0.847***	0.822***	0.550***	0.765***	0.923	0.673***	0.448***
Women's health care decision husband	0.906***					0.980				
Women's health care decision husband x EM	0.969					1.194***				
Heard of family planning		1.283***					1.465***			
Heard of family planning x EM		-0.001					0.658***			
Visited health facility			2.010**					3.387***		
Visited health facility x EM			0.949					0.615**		
Health facility told family planning				1.492***					1.363***	
Health facility told family planning x EM				0.976					0.743	
Distance to health facility problem					0.980					0.736***
Distance to health facility problem x EM					1.079*					1.101
N (matched sample)	119,334	124,101	122,651	77,584	110,130	63,660	67,304	9,882	8,404	57,170

Notes: (1) For details on the construction of matched samples see Online Appendix 3. (2) * p < 0.10, **p < 0.05, ***p < 0.01.

ONLINE APPENDICES

Online Appendix 1: List of countries

Our analysis includes the latest available DHS surveys from Sub-Saharan Africa (SSA) and South West Asia (SWA). There are 34 countries/surveys in SSA and 5 countries in SWA (see Table 1).

Table 1
Countries included in the analysis

Sub-Saharan Africa	Year	South West Asia	Year
Benin	2011	Bangladesh	2011
Burkina Faso	2010	India	2005
Burundi	2010	Maldives	2009
Cameroon	2011	Nepal	2011
Chad	2004	Pakistan	2012
Comoros	2012		
Congo	2011		
Côte d'Ivoire	2011		
D. R. Congo	2013		
Ethiopia	2011		
Gabon	2012		
Gambia	2013		
Ghana	2008		
Guinea	2012		
Kenya	2008		
Lesotho	2009		
Liberia	2013		
Madagascar	2008		
Malawi	2010		
Mali	2012		
Mozambique	2011		
Namibia	2013		
Niger	2012		
Nigeria	2013		
Rwanda	2010		
Sao Tome and Principe	2008		
Senegal	2014		
Sierra Leone	2013		
Swaziland	2006		
Togo	2013		
U. R. Tanzania	2010		
Uganda	2011		
Zambia	2013		
Zimbabwe	2010		

Online Appendix 2: Effects of timing of marriage on health outcomes by Sub-Saharan Africa regions

We also carry out multitreatment estimations for SSA sub-regions to find out whether the whole sample results of SSA are driven by specific sub-regions. Results for selected outcomes are shown in Table 2. First, for early married mothers (EMM) health outcomes, the positive effects of postponing early marriage (EM) seem to be mainly explained by Southern Africa (SA) and Western Africa (WA), where the delaying early marriage is associated with impacts on antenatal visit numbers around 5-6 times larger than for Middle Africa (MA) and Eastern Africa (EA). Moreover, with a estimated impct of 0.07, SA also plays a leading role for the association of timing of EMM and the outcome skilled birth attendant. Though, for postnatal services, significant effects hold for MA and WA, and the benefits for the youngest EMM group is large (e.g.., the contrasting effect t1 vs t0 is significant for MA whilst t2 vs t1 is not significant). Overall, regional estimates for women's health care indicators are likely to be reflecting supply constraints facing SSA's poorest regions where larger child marriages happening in rural areas.

Table 2
Effect of age of marriage (multitreatment effects) on selected mother's health care and children's health
outcomes and children's health by SSA regions

	Middle Africa	Eastern Africa	Southern Africa	Western Africa
Panel A - Mother's health care outcomes				
Antenatal visits numbers				
t1 vs t0	-0.030	-0.061***	0.198*	0.159***
t2 vs t0	0.126***	0.028*	0.628***	0.662***
t2 vs t1	0.156***	0.089***	0.429***	0.502***
Skilled birth attendant				
t1 vs t0	-0.005	0.006**	0.045***	0.005***
t2 vs t0	0.001	0.038***	0.073***	0.023***
t2 vs t1	0.006**	0.032***	0.028***	0.017***
Postnatal checks				
t1 vs t0	0.012*	0.004	-0.040	0.040***
t2 vs t0	0.018**	0.003	-0.037	0.073***
t2 vs t1	0.005	-0.001	0.003	0.032***
Panel B - Children's health outcomes				
Child basic vaccinations				
t1 vs t0	0.015***	0.036***	0.120***	0.034***
t2 vs t0	0.017***	0.039***	0.086***	0.051***
t2 vs t1	0.003	0.003	-0.035	0.017***
Neonatal mortality				
t1 vs t0	-0.001	-0.010**	0.020	-0.003
t2 vs t0	-0.002	-0.001**	0.009	-0.004*
t2 vs t1	-0.001	0.000	-0.010	-0.001
Infant mortality				

t1 vs t0	-0.010*	-0.011**	0.052**	-0.006*
t2 vs t0	-0.011*	-0.017***	0.037*	-0.011***
t2 vs t1	0.000	-0.006**	-0.015	-0.005**

Notes: (1) Delta-method standard errors. * p < 0.10, **p < 0.05, ***p < 0.01.

There are two salient results with regards to children's health outcomes. First, the positive effect of postponing EM in terms of children's vaccination uptake is equally shared among SSA regions (though the benefits are larger for SA), especially for children of the youngest married women cohort. For example, if women had not married between age 10-14 and instead married between age 15-17, this would have led to larger vaccinations rates of 1.5%, 3.6% and 12% for MA, EA and SA respectively, whereas deferring age of marriage from ages 15-17 to age 18 or afterwards would not have had any significant impact. Second, the direct association of delaying EM with neonatal and infant mortality for SSA it is mainly driven by the EA region. Once more, the benefits on reducing mortality rates are greater for the youngest EM group (-0.010 vs 0.000 for neonatal mortality and -0.011 vs -0.006 for infant mortality) which clearly highlights what can be accomplished in the short term by keeping girls away from marriage at least for a few years.

Online Appendix 3: Construction of matched subsamples - propensity score matching

Because early marriage (EM) is not only a deeply-rooted cultural phenomenon but also a socioeconomic strategy of survival driven by poverty and lack of education opportunities, EMM and non-EMM will differ on the observable characteristics. This, in turn, will affect their intrahousehold bargaining power on health decisions due to their lack of maturity [1, 2] and access to health facilities as mostly EM arrangements take place in isolated poor rural communities. Hence, we attempt to control for the selection bias generated by confounding factors by matching methods achieving a balance on the distributions of observed covariates between treated (EMM) and untreated (non-EMM). In particular, by comparing EMM and non-EMM with the similar level of education and household's wealth as well as living in communities with equivalent level of development and country variables, we can reduce the bias affecting the estimates.

We adopt the non-parametric propensity score matching which is a standard approach within program evaluation studies. [3, 4] The main purpose is to find a group of non-treated (non-EM) mothers who are similar to treated mothers (EM) so any difference on health outcomes can be attributed to the treatment – i.e., married before age 18. A key assumption, though untestable assumption for matching, is the conditional independence assumption (CIA) or selection into

treatment is only based on observables, and also the existence of common support or overlap condition:$0 < Pr((\mathrm{EM_i}|\mathrm{X}) < 1$, which requires that each individual has a positive probability of receiving each treatment level.

The propensity score is defined as the conditional probability of marrying young given pre-treatment characteristics: $\Pr((EM_i|X)$. We follow a nearest neighbor matching (1:1 matching without replacement) imposing the common support assumption (using the command psmatch2 in Stata). The technique consists of an algorithm that matches each treated EM women with the non-treated women with the closest propensity score. The proximity is regulated with the caliper. We employ a small caliper of 0.001 to minimise the differences in propensity score for the (large) matched samples used in subsequent analysis and the without replacement to reduce the overall standardised bias. Our conditioning covariates are the same as for the multitreatment model of Section 3.2 (see Table 3) plus parental education and wealth household.

Figure 2 shows the balance achieved on the treated and untreated covariates after matching. We plot as examples the distribution of key covariates such as household wealth, mother's education, community fertility rate (approximated by the community average proportion of children under age 4) and the development index of the community (the development index is based on household assets and proportion of fathers in with upper non-farm occupation) before and after matching. Using a tighter calliper leads to an improvement on the overlapping on the distributions for the populations showing disadvantage – i.e., bottom wealth quintiles, low level of mother's education and development index and larger fertility rates for the less disadvantaged non-EMM (untreated) group. In the same way, Figure 3 shows the proximity on the conditional probability of being treated for EMM and non-EMM obtained through matching. In particular, there is an improvement for the SWA region with large discrepancies on propensity scores for the full sample before matching while, after matching, propensity scores overlap.

Full details and statistics of the quality of matching alongside average treatment for the treated (ATT) estimates are displayed in Table 3. The standardised percentage bias of the sample means before and after matching [5] is reduced from an average of 24.9% to 0.3% across SSA's working samples and from 32.3% to 1.2% in SWA. In SSA, there are no significance differences on covariates by t-tests (at 5% level), while in SWA a few covariates remained

different after matching for half of the health outcomes samples. In either region, the B and R statistics fall into the correct interval and are not a matter of concern. Thus, we are satisfied with the performance of matching across SSA and SWA samples. As a result of matching, the matched or pruned sample is considerably reduced in size. The final sub-samples with matched EMM and non-EMM are one quarter and one third smaller than the full sample in SSA and SWA, respectively.

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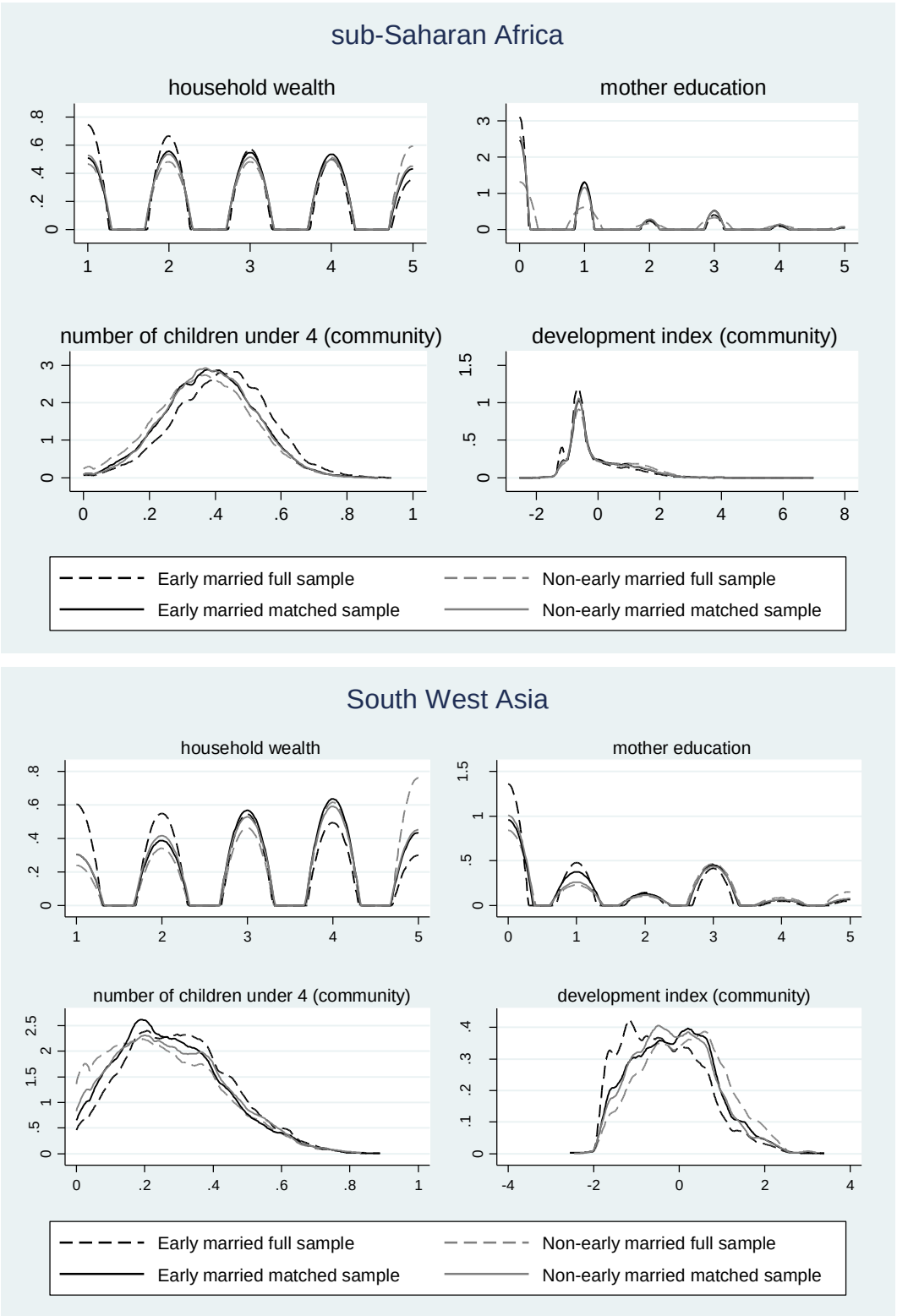

Figure 1. Distribution of covariates in full and matched sample.

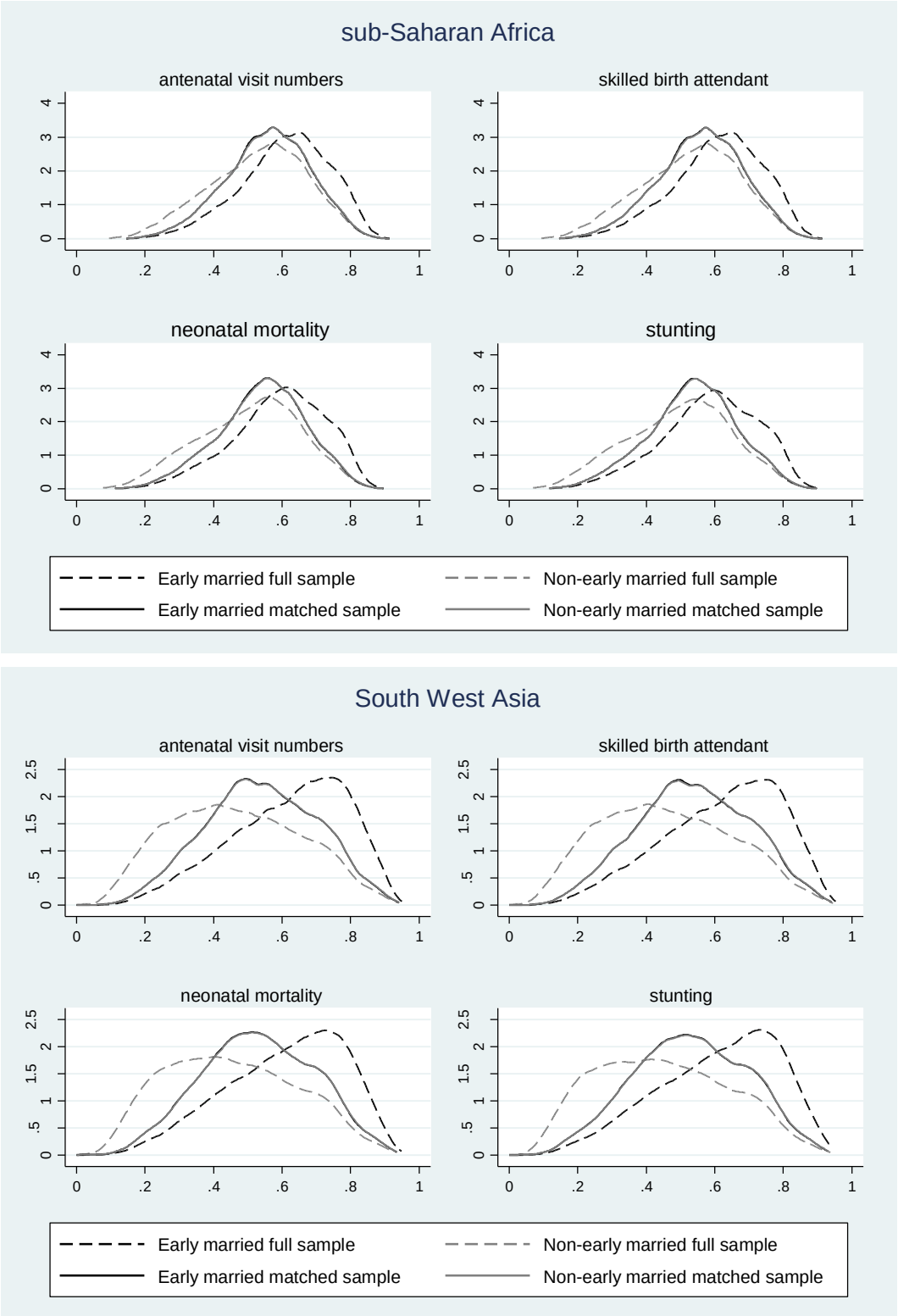

Figure 2. Estimated propensity score before and after matching. Treatment: early married (EM

Table 3
Average treatment on the treated (ATT) effects of early marriage (nearest neighbour matching without replacement)

Samples	Antenatal visits numbers	Vaccination neotetanus	Skilled birth attendant	Postnatal check	Child basic vaccinations	Neonatal mortality	Infant mortality	Stunting
SSA region								
Early marriage (ATT)	-0.341***	-0.035***	-0.023***	-0.028***	-0.033***	0.004***	0.010***	0.035***
Caliper	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
t-test (diff sign)	0 X	0 X	0 X	0 X	0 X	0 X	0 X	0 X
Mean bias (unmatched)	23.7%	23.9%	27.2%	23.3%	25.2%	25.1%	25.1%	25.5%
Mean bias (matched)	0.4%	0.4%	0.3%	0.3%	0.4%	0.3%	0.3%	0.3%
B Rubin and R	1.5, 1.00	1.4, 1.02	1.7, 1.05	1.9, 1.09	1.8, 1.09	1.5, 1.03	1.5, 1.03	1.6, 1.07
Sample	207,614	209,463	209,617	169,870	171,753	49,100	49,100	37,983
Matched sample	152,960	154,300	154,282	123,488	125,942	36,648	36,648	28,392
SWA region								
Early marriage (ATT)	-1.100***	-0.026***	-0.078***	-0.004	-0.066***	0.005***	0.008***	0.064***
Caliper	0.001	0.001	0.001	0.001	0.001			
t-test (diff sign)	3 Xs	6 Xs	7 Xs	4 Xs	8 Xs	0 X	0 X	1 X
Mean bias (unmatched)	33.4%	33.6%	33.8%	23.3%	31.2%	33.9%	33.9%	35.0%
Mean bias (matched)	1.1%	1.4%	1.4%	1.5%	1.6%	0.9%	0.9%	1.0%
B Rubin and R	4.6, 0.9	5.5, 0.87	6.0, 0.81	6.5, 0.96	6.2, 0.81	4.2, 0.82	4.2, 0.82	5.5, 0.78
Sample	105,582	105,896	104,713	62,188	105,070	27,830	27,830	21,544
Matched sample	68,426	68,588	67,308	36,920	67,322	18,200	18,200	13,976

Notes: (1) t-test ok if differences between matched and comparisons are non-statistically significant at 10%. (2) Ideally mean bias should be below 5%. (3) Rubin's B (with R) ok if B>25%, R outside [0.5; 2]. (3) . * p < 0.10, **p < 0.05, ***p < 0.01.